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Righting a Million Bushel Elevator

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THERE are few engineering undertakings that are more spectacular and appeal more to the imagination than the righting of the Transcona Elevator.

About ten years ago, the Canadian Pacific Railway, to facilitate the speedy shipment of grain from the Canadian Northwest, built a one-million-bushel grain elevator near Winnipeg. It was of reinforced concrete and consisted principally of a workhouse seventy feet by ninety-six feet and one hundred eighty feet high and a bin house seventy-seven feet by one hundred ninety-five feet and one hundred two feet high. The latter was made up of sixty-five circular bins fourteen feet four inches in

should safely carry a load of from three to four tons per square foot. The ultimate loading of the clay under the mat was calculated for this structure to be three and three-tenths tons per square foot. It was therefore assumed, after a slight initial settlement, there would be no difficulty.

The Canadian Pacific Railway began storing grain in the Transcona Elevator in September, 1913. Care was taken to fill the bins so that the load would be uniformly distributed. On October 18, with 875,000 bushels in the bins, settlement was first noted and a vertical settling of one foot took place within an hour. Within twenty-four hours, the bins had leaned



GRAIN ELEVATOR UPSET BY DEFECTIVE FOUNDATION

diameter. These and the diamond-shaped spaces between afforded the storage capacity of approximately one million bushels. Both the workhouse and the bin house were equipped with the most modern conveying machinery for rapidly loading and unloading cars.

The whole structure—workhouse and bin house—rested on a floating foundation of reinforced concrete. The supporting mat for the workhouse was fifteen feet below the prairie level. For the bin house it was twelve feet below at which elevation the soil was found to be firm gray clay extending to a depth of about forty feet. In supporting the elevator on a floating foundation, the customary practice of that part of Canada was followed. Soil

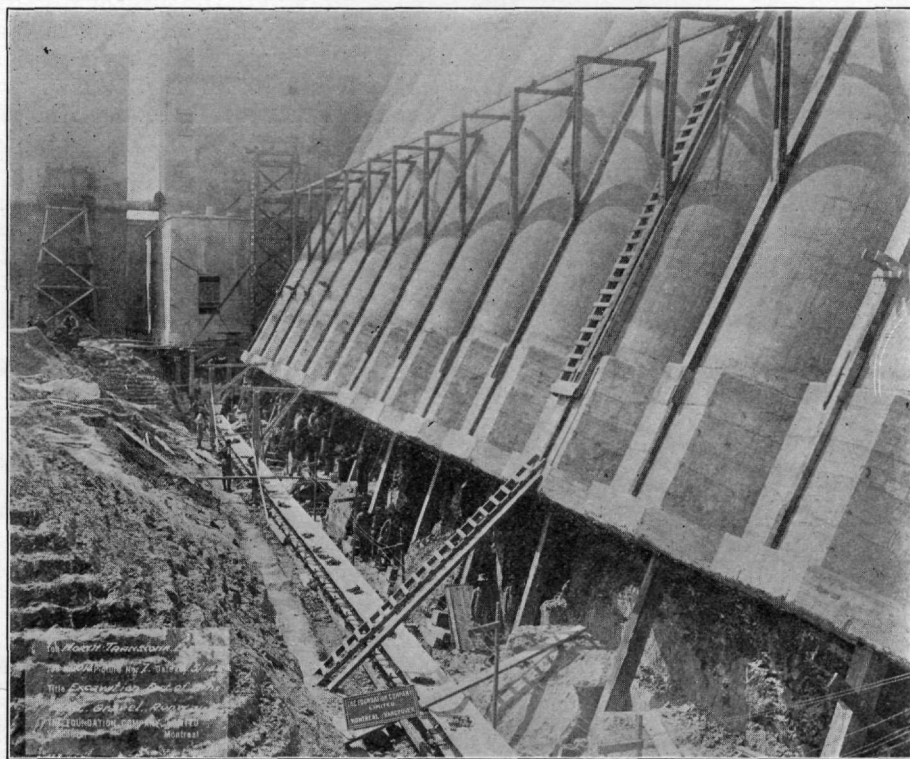
to the west twenty-seven degrees. The lower tests were made and it was found that the clay side was twenty-nine feet below its original position and the higher about five feet above its original position. Only the upheaval and compacting of the soil on the west side prevented the complete overturning of the structure, which in fact was found to be in a most hazardous position with its center of gravity dangerously near the lower edge.

The railway engineers, confronted with an unprecedented problem, appealed to the leading firms specializing in engineering construction requesting that schemes and estimates for saving the grain elevator be presented without delay. The rivalry to produce a practicable

plan was keen and finally the Canadian Pacific adopted the scheme of The Foundation Company as being not only the most practicable, but also the most novel. It included some features which might be characterized as daring but it also promised economy.

Among the first steps taken by the Canadian Pacific after the failure of the elevator was to get the grain out. This was done in three weeks by tapping the bins through the sides. Conveyors brought from Chicago assisted in the operation and when the contractor began work he found an empty structure weighing twenty thousand tons. Strangely the bin house was not materially damaged by the rough treatment it had received. This is one of the most striking evidences on record of the strength and practicability of reinforced concrete. The cover photo

the construction company were therefore concentrated at first on this tall narrow concrete structure. The columns must be underpinned to rock. On account of the height of the structure, its small base and the heavy loads, it was necessary to shore the building before starting operations under the columns. For this purpose twenty small piers were sunk to rock around the outside of the workhouse. These afforded a sure footing for shores to each outside column. The next step was to sink piers to rock directly under each of the twenty-four columns. Generally, the Chicago well method was followed in the construction of the new foundations. Wells five feet in diameter were used. The underpinning operations were carried on with great care, and extraordinary devices such as a two hundred eighty-pound plumb bob suspend-



RIGHTING THE ELEVATOR

Note the difficulty of sinking pier to rock under each of the twenty-four columns.

shows how the elevator looked in December, 1913, when the Foundation Company started work. An investigation of subsurface conditions showed that the clay which had been found to be stiff at the elevation of the reinforced concrete supporting mat, was very soft between elevation —30 and —40. The displacement of this soft stratum was apparently the cause of the failure. A line of boulders under the east side of the bin house explained the tipping to the west. Rock was found to be about fifty-five feet below the prairie level.

The scheme adopted for salving the structure involved not only righting the bin house but the sinking of piers to rock for the support of the workhouse and the bin house.

The railway engineers decided that the uncertain condition of the workhouse demanded that it be given first attention. The efforts of

ed from a height of one hundred sixty feet were adopted to detect undesirable movements. In spite of the treacherous subsoil conditions and the hazards involved, the underpinning of the workhouse which had been begun in December, 1913, was completed without mishap in June, 1914.

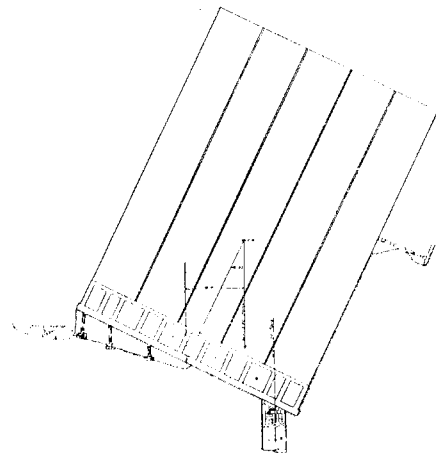
In February 1914, the Foundation Company was ordered to proceed with the straightening of the bin house and thus the most spectacular part of the work was begun. The empty structure weighed twenty thousand tons and the problem was to right it and underpin it to rock. For the sake of economy, it was decided not to raise the structure to its original elevation but merely to rotate it into a vertical position around the west or low edge. This

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would leave the mat in its final position at about thirty-eight feet below the prairie level.

Figure 1 shows the elements of the scheme to right the bin house. First piers were sunk to rock under the low edge. These were to afford a support for the fulcrum on which the structure was to be rotated and later to become part of the permanent foundations. Righting motion was produced by weakening the core of earth under the high side and by a line of pushers along the west side. The sinking of wells for piers was greatly complicated by water which flowed into most of them at the rate of over one thousand gallons per minute. The whole undertaking was made difficult by the congestion under the structure where the work had to be carried on. The contractor was constantly called upon to resort to special devices. When the fourteen piers under the low side were nearing completion, work on the remaining fifty-six piers was started and was continued during the straightening process. Wells for piers were of the Chicago type seven feet in diameter. While work was in progress, the railway engineers decided that it would be desirable to have the mat of the structure righted above the ground water level instead of below as it would be at —38. To accomplish this end, the structure was rotated on the fulcrum under the west side through about ten degrees. Then the fulcrum was changed to the next row of piers and the structure rotated through about eight degrees. In this manner, the fulcrum was shifted three times and the bin house actually lifted more than twelve feet. Today in its vertical position it is about fourteen feet below its original position. It was not raised to its original level because it satisfactorily serves its purpose as it is.



(Plan to right the bin-house.)

The task of righting the bin house was started about March, 1914. It was completed October 17—within two days of the estimated time. As in the case of the workhouse, precautions were necessary throughout the operation and it was completed without mishap. Measurements to detect movement or dangerous stresses in the structure were taken twice daily. The success of the undertaking depended absolutely upon the fidelity of the engineers.